

Interactive comment on “An urban microwave link rainfall measurement campaign” by Thomas C. van Leth et al.

Anonymous Referee #1

Received and published: 1 January 2018

General comment:

The manuscript describes dedicated experiment designed to investigate different phenomena influencing rainfall retrieval from microwave links. Several microwave links were installed over same path and equipped with time lapsed cameras shooting antenna surfaces and the link path. In addition, array of disdrometers completed with rain gauges were placed along the link path. Finally, additional observations from nearby weather station such as temperature, humidity or wind speed were used to interpret phenomena occurring during the measurement campaign. The manuscript goal is to provide comprehensive overview of different phenomena causing attenuation of microwave links and evaluate their relevance for rainfall intensity retrieval, specifically to the rainfall retrieval algorithm as suggested by Overeem et al. (2011 and 2016). The

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first goal is scientifically relevant as i) it might improve understanding of uncertainties affecting microwave link rainfall retrieval and ii) description of attenuation patterns from other phenomena than rainfall is crucial for improving baseline separation algorithms. The presented experimental setup is very well suited to provide reliable dataset to reach this goal. The second goal is bit too specific to the selected processing algorithms (Overeem et al. 2011 and 2016).

The manuscript focuses on describing different phenomena causing link attenuation on several selected events. Overall statistical evaluation is mostly not provided which hinders quantitative assessment of the influence of these phenomena on microwave link rainfall retrieval. Results are often presented qualitatively in subjective manner (e.g. 'link is remarkably stable') even in cases where it could be easily described quantitatively, for more details see specific comments. Authors should distinguish in the whole result section more properly if the attenuation occurs along the link path or if it is rather related to hardware of microwave link radio units/antennas. The ambiguous cases should be then properly discussed and possibly confronted with radio wave propagation theory or results of other studies.

The manuscript is well structured, however, stylistics might be still improved, e. g. paragraphs in the result section could be more concise and fluent.

Specific comments:

P7L28: Results and discussion section: The results of microwave links are in the text mostly presented in mm/h although figures show also dBs. I strongly recommend to present the results also in dBs and compare them with theoretical rain induced attenuation from disdrometer data (eq. 3). The main reasons are these i) the uncertainties arising from imperfect separation of rain-induced attenuation are mixed with uncertainties arising from rainfall-attenuation power-law model, i.e. variability of α and β parameters (Tab. 2) during different rainfall events and uncertainties due to path-integration of attenuation and nonlinearity of power-law model. This hinders interpretation of results.

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ii) Substantial part of link attenuation unexplained by raindrops are hardware related errors (e.g. due to wet antenna or quantization noise). Such uncertainties expressed in mm/h apply only to links of the same lengths as in the experiment. iii) Most of the literature concerning microwave link propagation and different phenomena influencing radio wave attenuation (including wet antenna attenuation) express results in dBs.

P8L5: It is stated here that in the presented event there are 'no attenuation-inducing influences other than rain', however, this is inexact as the radio waves are during this event for sure attenuated e.g. by atmospheric gases, there is a free space loss, etc.

P8L33: There are certainly various attenuating phenomena (see comment P8L5) influencing link attenuation, and drop down in the RAL link signal level has probably some (unknown?) reason.

P9L4: 'remarkably stable' or 'uncertain baseline' is very subjective description. Please quantify.

P9L17-20: The causes of outliers and overestimation discussed in these lines are speculative. The experimental design should enable investigate unexpected behavior of links much more specifically thanks to reliable ground truth, cameras, etc. For example, it is stated here that 'overestimation and outliers could be attributed to attenuating phenomena ... erroneously processed as rain in the basic algorithm'. It should be, however, possible to check against disdrometer data if the errors are due to the processing algorithm. Similarly, errors introduced by k-R model can be estimated and it should be verified if they can explain underestimation.

P10L22-24: Please quantify the magnitude of oscillations.

P10L33: Is the 90 % humidity threshold selected arbitrary, based on radiowave propagation theories, or estimated by regression itself? Please indicate.

P11L13-15: The statement that 'the temperature dependence of the Nokia link is drowned out in the noise' is speculative as you cannot prove there is a temperature

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dependency if it is 'drowned out in the noise'. If you can prove it (at reasonable confidence level) it is then not 'drowned out in the noise'.

P11L19: Please indicate in the text the duration of antenna wetting and drying quantitatively. The figures depict too long period to distinguish if the processes take place only few minutes, tens of minutes or few hours.

P11L31-32: Please describe more precisely what is meant with 'quite different pattern'. Different range, variability, autocorrelation structure, ...?

P13L11-12: What is meant with 'any other atmospheric phenomena'? Furthermore, the following text relates the attenuation to the humidity which is an atmospheric phenomena. The whole meaning of this sentence is, therefore, unclear.

P13L15-22: The antenna drying times might be very much influenced also by other environmental variables such as wind or sun radiation. Could e.g. wind which is also displayed in the figs 16 and 17 explain part of the uncertainty in drying duration? Is there any reason why humidity is included in the quantitative analyses and not the wind?

P14L20: A robust evidence that the link response to the additive and multiplicative bias is consistent over different events has not been provided in the previous text. Why don't you e.g. quantify both additive and multiplicative bias for each event and link and provide information about range and variability of both types of biases?

Figures: There is a wrong legend in the panel (a) of the figures 5, 6, 8, 9, 10, 12, 15, 16 and 17 as RAL 38 V is assigned to both blue and green lines. It seems to be that green line belongs to the RAL 38 H and the orange one to the RAL 26 V, i.e. same coding as in the panel (b).

References:

Overeem, A., Leijnse, H. and Uijlenhoet, R.: Retrieval algorithm for rainfall mapping from microwave link in a cellular communication network, Atmos. Meas. Tech., 9,

2425-2444, doi: 10.5194/amt-9-2425-2016, 2016.

Overeem, A., Leijnse, H. and Uijlenhoet, R.: Measuring urban rainfall using microwave links from commercial cellular communication networks, *Water Resour. Res.*, 47, W12505, doi: 10.1029/2010WR010350, 2011.

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